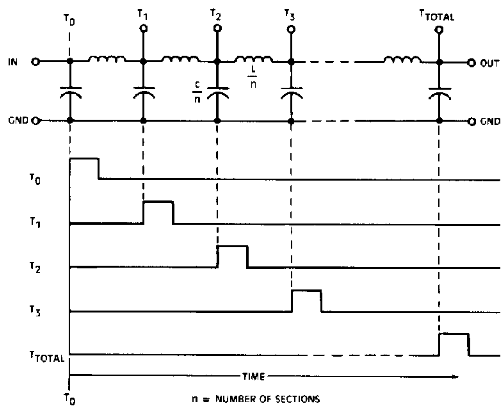
DELAY LINE CHARACTERISTICS

Delay Time

Total delay time of a delay line is expressed in terms of total inductance and total capacitance as follows:

$$T_D = \sqrt{LC}$$

Where: T_D = Total delay time in microseconds (μsec)
L = Total inductance in microhenries (μh)
C = Total capacity in micro-farads (μf)



amount predetermined by the electrical spacing, as it propagates through the delay line to the output

Impedance

All unbuffered (passive) delay lines must be terminated into their characteristic impedance. The characteristic impedance is the amount of terminating resistance resulting in minimum amount of reflection when viewed at the input end of the delay line. The value generally is chosen to match the characteristic impedance of the circuit environment. Impedance is measured in ohms, and expressed in terms of inductance and capacitance as follows:

$$Z_O = \sqrt{\frac{L}{C}}$$

Restricting factors affecting impedance are encountered when discrete values become impractical to build, when stray inductance and capacitance become a significant portion of the discrete components of the delay line, or when dc resistance or insertion loss must be lowered. Generally, this affects only delay lines with higher values of delay and impedance.

Rise Time

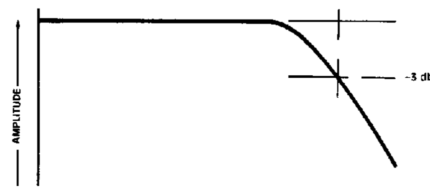
One measure of how faithfully a pulse is reproduced as it passes through the delay line is the amount of time required by the pulse to travel through the specified amplitude levels (usually 10% to 90% point) of the leading edge (pulse rise time). The true rise time of a network may be calculated by:

$$T_R = \sqrt{(T_{RO})^2 - (T_{RI})^2}$$

Where: T_R = NETWORK RISE TIME
T_{RO} = OUTPUT RISE TIME
T_{RI} = INPUT RISE TIME

Bandwidth

Acknowledging the fact that a delay line is also a low pass filter, rise time can therefore also be defined as a function of bandwidth.



If the frequency of the signal passing through the delay line is varied, the frequency at which the signal amplitude is "down" 3db (-3db attenuation) is defined as the bandwidth frequency of the delay line. Rise time is therefore approximately equal to:

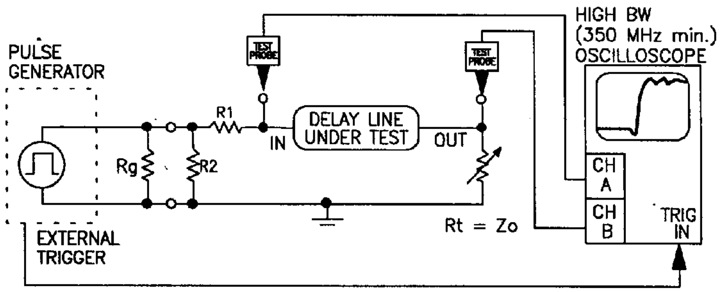
$$T_{R(\mu SEC)} = \frac{0.35}{BW\,(MHz)}$$

Figure of Merit

Delay lines intended for pulsed data applications may be specified by their desired figure of merit ratio. This ratio is expressed as:

$$\frac{T_D}{T_R}$$

In electromagnetic delay lines, it is the total value of capacitance and inductance that determines the overall delay time. However, since in lumped constant delay lines several or many sections are used, the value of capacitance or inductance of each individual section is the total network value of L or C divided by the total number of sections. Since the frequency response of a single low pass section increases with reduced values of L and C, it then follows that for a given delay time the figure of merit also increases.



Rg = GENERATOR SOURCE IMPEDANCE = 50 OHMS
R1,R2 = INPUT MATCHING PAD RESISTORS
Rt = TERMINATING RESISTOR
Zo = DELAY LINES CHARACTERISTIC IMPEDANCE

$R1 = \{Rg \times Zo\} / R2$

$R2 = \sqrt{\frac{Rg^2 \times Zo}{Zo - Rg}}$

Figure 5A. Recommended test circuit for Passive Delay Lines

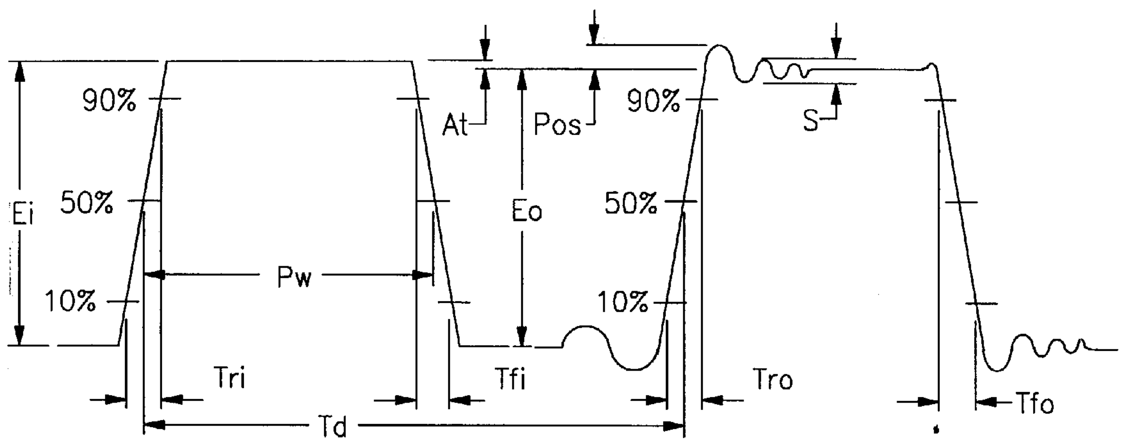


Figure 6A. Passive Delay Line Waveform Parameters

GLOSSARY

LEADING EDGE: that portion of the pulse which rises from zero to peak amplitude.

TRAILING EDGE: that portion of the pulse which falls from peak amplitude to zero.

INPUT VOLTAGE (Ei): the amplitude of the input pulse.

OUTPUT VOLTAGE (Eo): the amplitude of the output pulse.

DELAY TIME (Td): the elapsed time between the respective 50% points on the leading edges of the input and output pulses.

INPUT RISE TIME (Tri): the elapsed time between the 10% and the 90% points on the leading edge of the input pulse.

INPUT FALL TIME (Tfi): the elapsed time between the 90% and the 10% points on the trailing edge of the input pulse.

OUTPUT FALL TIME (Tfo): the elapsed time between the 10% and the 90% points on the leading edge of the output pulse.

OUTPUT FALL TIME (Tfo): the elapsed time between the 90% and the 10% points on the trailing edge of the output pulse.

PULSE WIDTH (Pw): the elapsed time between the 50% points on the leading and trailing edge of a pulse.

PULSE OVERSHOOT (Pos): the peak amplitude of overshoot occurring at the top of the leading edge of the output pulse (for flat input pulse top).

PULSE DISTORTION (S): the magnitude of the largest peak amplitude of all spurious responses in either a positive or negative direction occurring in the period after the top of the leading edge of the output pulse and before two time delays (for flat input pulse top).

IMPEDANCE (Zo): the effective impedance of the delay line which is equal to the value of the terminating impedance which provides a minimum reflection back to the input of the delay line.

D.C. RESISTANCE (DCR): The D.C. resistance, in ohms, measured between the input and output of a delay line.

Attenuation (At): the difference in peak amplitude between input and output pulses.

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